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50. Internationales Wissenschaftliches Kolloquium
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R. Stephan / K. Blau / M. A. Hein

Electromechanical Resonances of SiC and AlN Beams under Ambient Conditions

ABSTRACT

MEMS resonators offer great potential for RF sensor and filter applications. A semiconductor process has been used to prepare SiC and AlN beam resonators. The metallised beams are excited by a RF current in a permanent magnetic field. The resonant response is detected by the induced voltage. Despite the weakness of the signal, accurate detection has been achieved in the time domain, under ambient conditions in a magnetic field of about 0.5 T. The resonant response bears valuable information on the structural quality of the material.

RESONATOR STRUCTURE AND MEASUREMENT SETUP

Mechanical oscillations in semiconductor materials have been demonstrated by several groups, e.g., [1,2]. Typically, the mechanical resonance is stimulated by periodic energy supply, and the resulting vibration is detected electrically. Here, the basic resonator structure is a doubly clamped beam that is actuated magnetomotively, i.e. by Lorentz-force drive and induced voltage detection, Fig. 1a.

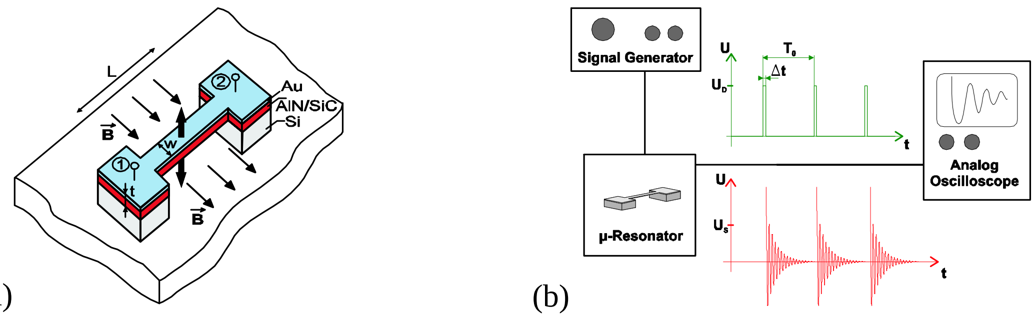

Fig. 1. (a) Mechanical resonator of beam length *L*, width *w* and thickness *t*, in a magnetic field of flux density *B*. The bold arrows: direction of the Lorentz-force and beam deflection.
(b) Schematic measurement setup, diagrams of excitation and read-out time signal.

Using optical lithography, beams were prepared in various dimensions. They consist of a ~10^2-nm thick AlN or SiC(100) layer with a 50-nm thick gold metallisation on top. The beams vary in length and width from 10 to 500 µm and 500 nm to 8 µm, respectively. Based on the Euler-Bernoulli theory [3] and on results obtained from a commercial finite-element simulation software [4], calculated resonant frequencies f_{sim} range from 3 kHz to 1 MHz for AlN, and 26 kHz to 17 MHz for

SiC. The oscillation of the beams is caused by a RF current, driven by a primary voltage of the order of Volts. The induced secondary voltage, is much smaller than the primary voltage, of the order of µV, and therefore difficult to detect as a tiny background signal. To overcome this problem, we excited by short voltage pulses and monitored the free decay with an oscilloscope and hence separated excitation and response signal of the resonator in time. The periodic response yields the information on the resonant frequency f_{res} and the loaded quality factor Q of the resonator.

RESONANT FREQUENCIES AND QUALITY FACTORS

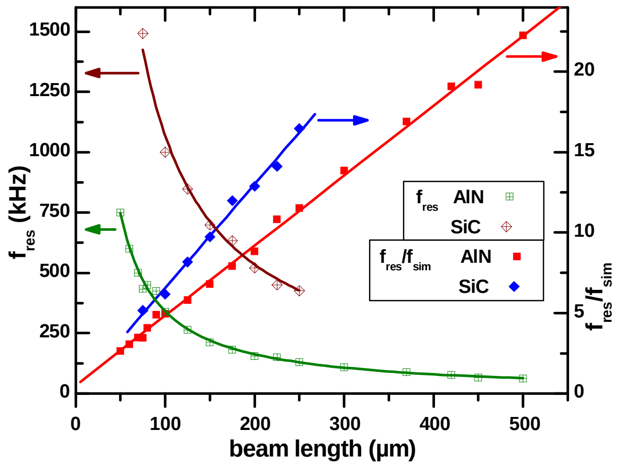

Fig. 2. Frequency versus beam length for the doubly clamped SiC and AlN beams.

The measured f_{res}-values covered the range from 6 to 750 kHz for the AlN beams, and 0.32 to 1.5 MHz for the SiC beams. Fig. 2 compares the dependence of the resonant frequencies (left-hand scale), and the ratio $n = f_{\mathrm{res}}/f_{\mathrm{sim}}$ (right-hand scale), on beam length for both materials. The linear increase in the n (L)-curves indicates residual axial strain, which could be determined to $e \approx +5\times10^{-5}$ for the AlN- and $e \approx +5\times10^{-4}$ for the SiC-beams [5].

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